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(तीसरा पुनरीक्षण)

Indian Standard

ELECTROPLATED COATINGS OF HARD CHROMIUM FOR ENGINEERING PURPOSES — SPECIFICATION

(Third Revision)

First Reprint NOVEMBER 2000

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

March 1993 **Price Group 4**

AMENDMENT NO. 1 JUNE 1999
TO
IS 1337 : 1993 ELECTROPLATED COATINGS OF HARD CHROMIUM FOR ENGINEERING PURPOSES — SPECIFICATION

(Third Revision)

(*First Cover page , Hindi Title, line* 1) — Delete the words ' लौहे और '.

(*Page* 3, *clause* 7.5.3) — Insert the following matter after 7.5.3:

'Wherever it is not possible to evaluate the micro-hardness on the component, the measurements can be made on a dummy flat plate of thickness 5.0 mm, *min* plated under identical conditions along with component (with base metal as required) and as agreed between the purchaser and the supplier. '

(*Page* 3, clause 7.6.1, *line* 4) — Substitute '7.6.2' *for* '7.6.3'.

(*Page* 4, *clause* 8.1, *line* 6) — Substitute '10.1' *for* '9.1'.

(MTD 20)

Printed at New India Printing Press, Khurja, India

Metallic and Non-Metallic Finishes Sectional Committee, MTD 20

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Metallic and Non-Metallic Finishes Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1959 and was revised subsequently in 1968 and 1980. While reviewing the standard in the light of experience gained during these years, the commitee decided that standard may be further revised so as to bring it in line with international standard. In this revision, following changes have been made:

a) The scope of the standard has been widened,

b) The thickness of chromiun coating shall have to be specified by the purchaser, this is in view of the wide variety of industrial uses of chromium coatings,

c) Guidance on types and uses of chromium coatings are given in Annex A.

In the preparation of this revision, assistance has been derived from ISO 6158 : 1984 'Metallic coatings — Electroplated coatings of chromium for engineering purposes' published by the International Organization for Standardization, BS 4641 : 1986 'Metallic coatings — Electroplated coatings of chromium for engineering purposes', ASTM B 571-91 — Standard test methods for adhesion of metallic coatings published by the American Society of Testing and Materials.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ELECTROPLATED COATINGS OF HARD CHROMIUM FOR ENGINEERING PURPOSES — SPECIFICATION

(Third Revision)

1 SCOPE

This standard specifies requirements for electrodeposited chromium coatings with or without undercoats, on ferrous and non-ferrous metals for engineering purposes.

2 REFERENCES

The Indian standards listed below are necessary adjuncts to this standard:

IS No.	*Title*
1986 : 1981	Code of practice for hard chromium plating on iron and steel for general engineering purposes
3203 : 1982	Methods of testing local thickness of electroplated coatings (*first revision*)
9530 : 1980	Method of testing microhardness of electroplated coatings

3 TERMINOLOGY

3.1 For the purpose of this standard, the following definitions shall apply.

3.2 Significant Surface

The part of the article covered or to be covered by the coating and for which the coating is essential for serviceability and/or appearance.

3.3 Shot Peening

A controlled bombardment by shots on the surface to be electroplated, to induce compressive stresses in the surface of the basis metal.

3.4 Chromium Coating

An electroplated coating of substantially pure chromium.

4 INFORMATION TO BE SUPPLIED

4.1 Information to be supplied by the purchaser to the electroplater.

4.1.1 *Essential Information* — The electroplater shall be supplied with the following information:

a) The number of this Standard, IS 1337;

b) The nominal composition, or specification and metallurgical condition of the basis metal;

c) The necessity for any stress-relieving treatment before electroplating;

d) The necessity for any trteatment to induce compressive stress, for example, shot peening before electroplating;

e) The details of significant surfaces and of any surfaces that are not to be electroplated, and of any areas on to which the chromium coating may be allowed to extend. These details can be indicated, for example, by drawings or by the provision of suitably marked samples;

f) Any special requirements for, or restrictions on, pretreatment, for example, vapour blasting instead of acid pretreatment;

g) The minimum thickness of chromium to be deposited and, if undercoats are applied, the total electroplated thickness. A minimum thickness may be quoted if desired, especially for the building up of worn or over-machined parts. These dimensions shall be those of the finished surface after any grinding of the electroplated part;

h) The type of chromium coating required, that is, porous, crack-free, micro-cracked, duplex or regular;

j) The final surface finish of the chromium coating, for example, as-plated, ground or honed;

k) The type, size, extent and location of surface defects that can be tolerated.

m) Requirements for any heat treatment after electroplating; and

n) Any other special requirements.

4.1.2 *Additional Information*

The additional information listeed in (a) to (j) as applicable, shall be supplied by the purchaser, if necessary in consultation with the electroplater:

a) For reclaimed articles, the nominal composition, or specification and metallurgical condition of the basis material, or as much relevant information as is available;

b) Whether any defects in the coating in its final condition can be tolerated and, if so, the type, size, location and number permitted;

c) If applicable, the required surface roughness;

d) If applicable, the required coating hardness;

e) If applicable, the maximum porosity;

f) Whether a sampling procedure is required;

g) The method, as agreed between the purchaser and the electroplater, to be used to determine the required undercoat thickness (es);

h) The means of direct measurement, agreed between the purchaser and the electroplater, to be used to determine the final dimensions of the finished article; and

j) If applicable, the method to be used for an adhesion test.

4.2 Information to be Supplied to the Purchaser by the Electroplater

Before processing, the electroplater shall inform the purchaser of visible surface defects such as porosity, cracks or undesirable coatings that are revealed by preliminary visual inspection and will prevent the production of unsatisfactory electroplated finish.

5 TREATMENT OF BASIS METAL BEFORE ELECTROPLATING

5.1 General

The significant surface shall be examined by the electroplater for visible surface defects, such as porosity, cracks and undesirable coatings or any other defects detrimental to the final finish. Any defects shall be brought to the attention of the purchaser prior to any processing.

5.2 Stress Relief

Before being electroplated, parts shall, if specified, be stress relieved. The conditions set out in Table 1 shall normally be used, but different conditions, that is, suitable combinations of a shorter time at appropriate higher temperatures may be used if they have been shown to be effective. The heat treatment shall be carried out before the commencement of any preparation or cleaning treatment using aqueous solutions.

Table 1 Stress Relief Conditions Before Electroplating

Maximum Specified Tensile Strength of Steel, Rm (MPa)	Heat Treatment
Up to 1 050	None required
More than 1 050 up to and including 1 450	1 h minimum at between 190 and 220°C
More than 1 450 up to and including 1 800	18 h minimum at between 190 and 220°C
More than 1 800	24 h minimum at between 190 and 220°C

If stress relief is performed after peening or other cold working processes, the temperature shall not exceed 220°C. Parts with surface-hardened areas shall be stress relieved at 130 to 150°C for not less than 5 h, but shorter times at higher temperatures may be used if the resulting loss of surface hardness of the substrate is acceptable.

Stress-relieving heat treatment is not normally required for non-ferrous metals.

5.3 Peening

5.3.1 *Steels*

If peening is necessary to improve the fatigue strength, the peening intensity, unless otherwise specified, shall be such that, when measured by the method described in Annex B, the arc height is at least:

a) 0·3 mm for steels of tensile strength less than 1 100 MPa; and

b) 0·4 mm for steels of tensile strength 1 100 MPa or greater.

NOTE — Lower intensities may be necessary on thin sections to avoid distortion, but may not be fully effective in avoiding loss in fatigue strength.

Unless otherwise specified, the peening shall be performed so that the area concerned is completely covered, i. e. the ball marks completely overlap each other.

5.3.2 *Non-ferrous Metals*

For non-ferrous metals, the peening intensity shall be specified by the purchaser.

6 CONDITION OF BASIS METAL BEFORE PLATING

The surface to be plated shall be free from defects such as pits, porosity and cracks and shall have a finish comparable to that required in the finished article unless agreed otherwise.

7 COATING REQUIREMENTS

7.1 Appearance

7.1.1 The chromium coating on the significant surfaces of the product shall be smooth and free of visual defects such as blisters, pits, roughness, cracks, burned deposits, or uncoated areas. The boundries of electroplating that cover only a portion of the surface shall, after finishing as indicated in the drawing, be free of beads, nodules, jugged edges, and other detrimental irregularities. Imperfections and variations in appearance in the coating that arise from surface conditions of the basis metal (scratches, pores, roll marks, inclusions, etc) and that persist in the finish despite the observance of good metal finishing practices shall not be cause for rejection.

7.1.2 *Post-Treatment Grinding*

For parts that are electroplated and subsequently ground to size, the grinding shall be done with a proper coolant, never dry, and with a sufficiently light cut to prevent cracking.

7.2 Other plating defects such as minute pits and slight roughness may be accepted provided these are removed by grinding operation.

7.3 The extent of chromium build up at the edges of the deposit shall be according to the agreement between the purchaser and the plater.

7.4 Thickness of Coating

The finished minimum thickness of chromium on the significant surface and of any undercoat(s) shall be as specified by the purchaser [*see* **4.1.1** (g)]. The thickness of coating shall be determined by instrumental, chemical or microscopic methods as given in IS 3203 : 1982. Alternative methods (for example, magnetic or electromagnetic, or the use of micrometer) are available and may be used by agreement between the purchaser and the plater.

7.5 Micro-Hardness

7.5.1 Micro-hardness shall be measured after de-embrittlement treatment where applicable.

7.5.2 Micro-hardness shall be minimum 800 HV, when measured under 100 gf load.

7.5.3 Where micro de-embrittlement is carried out at a temperature higher than the range 190-210°C, the micro-hardness of the coating will be reduced. Minimum micro-hardness in this case shall be by agreement between the plater and purchaser. For determining micro-hardness, reference may be made to IS 9530 : 1980.

7.6 Adhesion

7.6.1 The deposit shall firmly adhere to the basis metal and shall not show any signs of exfoliation, blistering or uncoated areas when subjected to the test specified in **7.6.3**.

7.6.2 The coated article or designated test specimen shall pass one of the following test, or any special test particular to the function of the part as specified by the purchaser.

7.6.2.1 *Ductility test*

7.6.2.1.1 *Procedure*

7.6.2.1.2 *Preparation of test piece*

Prepare a coated test piece 150 mm long, 10 mm wide and 1·0 ± 0·1 mm thick as follows.

Polish a sheet of the appropriate basis metal, similar to that of the articles being coated, except that the sheet may be of soft brass if the basis metal is zinc alloy. Use a sheet that is sufficiently large to allow the test strip to be cut from it after trimming off a border at least 25 mm wide all round.

Electroplate the polish side of the sheet with chromium to a thickness of 25 μm under the same conditions and in the same bath as used with the corresponding articles.

Cut the test piece from the coated sheet with a guillotine or flat shear. Round or chamfer the longer edges of the test strip, at least on the plated side, by careful filling or grinding.

7.6.2.1.3 *Test*

Bend the test piece with the coated side in tension, by steadily applied pressure, through 180° over the mandrel until the two ends of the test piece are parallel. Ensure that contact between the test piece and the mandrel is maintained during bending. Examine the convex side of the bent test piece visually for cracks.

7.6.2.1.4 *Expression of results*

If there are no cracks in the chromium coating on the test piece which have propagated completely over the convex surface, coating is deemed to have passed the test.

NOTE — Short cracks in the chromium coating at the edges of the test piece do not indicate failure.

7.6.2.2 *File test*

Saw off a piece of the coated specimen and inspect it for detachment at the deposit substrate interface. Apply coarse mill file across the sawed edge from the substrate toward the coating so to raise it using an approach angle of approximately 45° to the coating surface. Lifting or peeling is evidence of unsatisfactory adhesion.

7.6.2.2.1 This technique is not suitable for thin or soft coatings.

7.6.2.3 *Heat and quench test*

Heat the coated article in an oven for a sufficient time for it to reach the temperature given in Table 2. Maintain the temperature of the oven within 10°C of the nominal. Coatings and substrates that are sensitive to oxidation should be heated in an inert or reducing atmosphere or a suitable liquid. Then quench the part in water or other suitable liquid at room temperature.

7.6.2.3.1 Flaking or peeling of the deposit is evidence of unsatisfactory adhesion. Blister may erupt during the heat and quench test when plating solution is entrapped in substrate surface pits or pores which are bridged by the deposit. If the deposited coating cannot be peeled or lifted from the substrate in an area adjacent to the blister(s), the appearance of blisters should not be interpreted as evidence of interior adhesion.

7.6.2.3.2 Diffusion and subsequent alloying of metal may improve the bond strength of electrodeposits. In some parts, a brittle layer may be created by the materials involved causing peeling due to fracture rather than poor adhesion. This would not give a correct indication of the as-plated bond strength.

7.6.2.3.3 This test is nondestructive if the procedure does not create unwanted effects on parts.

7.7 Porosity

The coating shall pass the tests described in Annex C.

7.7.1 *Ferroxyl Test*

The test shall be conducted as in Annexure C by treating the sample for 10 min. The parts fail if more than the number of pores specified by the purchaser per part or per unit area is found.

7.8 Special Requirements

Where special requirements like porous chromium is to be produced, the method of its production and the coating requirements shall be agreed between the purchaser and the plater.

8 REPLATING

8.1 Where coatings do not meet the requirements of this specification, they may be stripped, preferably by alkaline electrolyte stripping, and replated. As replating involves the risk of additional hydrogen take up, the heat treatment specified in **9.1** shall be carried out prior to plating.

9 SHOT PEENING BEFORE PLATING

9.0 Plating area of the high strength steels if shot peened before plating minimises the loss of fatigue strength during chromium plating and post treatments.

Table 2 Temperature Test Guide

(*Clause* 7.6.2.3)

Substrate	Chromium, Nickel, Nickel Chromium, Copper	Tin Temperature	Lead Tin/Lead Temperature	Zinc Temperature	Gold and Silver Temperature	Palladium Temperature	Rhodium Temperature
	°C	°C	°C	°C	°C	°C	°C
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Steel	250	150	150	150	250	350	185
Zinc alloys	150	150	150	150	150	150	150
Copper and copper alloys	250	150	150	150	250	350	185
Alluminium and alluminium alloys	220	150	150	150	220	220	185

9.1 The requirements of shot peening, where necessary shall be by agreement between the purchaser and the plater.

10. HEAT TREATMENT

10.1 When required by the purchaser, heat-treatment as described in **10.2** and **10.3** shall be carried out to reduce risk of damage due to hydrogen embrittlement.

10.2 Stress Relief Treatment

All steel parts having an ultimate tensile strength of 1 000 MPa or a hardness of 32 HRC and above that are machined, ground, cold-formed, or cold-straightened shall be heated to 190 ± 15°C for a minimum of 3 h before cleaning and electroplating or as otherwise specified by the purchaser. This is done to relieve damaging residual tensile stresses.

10.2.1 Some steels which have been carburized, flame-hardened or induction-hardened and subsequently ground, would be impaired by the treatment as in **10.2** and should, instead, be stress-relieved at a lower temperature, say, at 170°C for not less than 1 hour.

10.3 Hydrogen Embrittlement Treatment after Plating

Unless otherwise specified by the purchaser, or indicated on the drawing of the part, all steel parts having an ultimate tensile strength of 1 125 MPa or hardness of 35 HRC and higher shall be baked at 190 ± 15°C for a minimum of 8 h, within 4 h after plating to provide hydrogen embrittlement relief.

Guidance on heat treatment of steel parts after plating is given in Table 3.

NOTE — Where the proposed temperature for heat-treatment would be harmful, for example, for some surface hardened parts, a lower temperature for a larger time may be requested.

11. PLATING PROCESS

11.1 Unless otherwise specified by the purchaser the chromium coating shall be deposited directly on the surface of the ferrous metal.

11.2 For the method of plating, reference may be made to IS 1986 : 1981.

12. SAMPLING AND INSPECTION

12.1 Sampling for Production Control

Statistical quality control is recommended for controlling the quality of chromium plating. For this purpose it is recommended that samples for tests should be taken from a place in the plating bath where the thickness of deposit is expected to be minimum. The appropriate tests as specified in 7 shall be conducted on such samples.

12.2 Sampling for Acceptance of a Lot

For the purpose of acceptance sampling, 2 samples shall be selected from a lot consisting of 100 articles, or part thereof, are electroplated at one time in the same bath. The samples shall be subjected to the appropriate tests as specified in 7

12.2.1 *Criteria for Acceptance*

If these samples pass the tests, the sub-lot represented by them shall be accepted. If one or both the samples should fail, two further samples shall be selected from the same sub-lot and subjected to the tests. If these latter samples pass the tests, the sub-lot shall be accepted. If any of the second set of samples fails in any test, the sub-lot shall be rejected.

Table 3 Guidance on Heat Treatment of Steel Parts after Plating

Tensile Strength	Sectional Thickness of Parts	Maximum Period at 190 to 210 °C
N/mm²	mm	h
1 000 to 1 150	Less than 12	2
	12 to 25	4
	Over 25	8
Over 1 150 to 1 400	Less than 12	4
	12 to 25	12
	Over 25 to 40	24 (Heating to commence within 16 hours of plating).
	Over 40	Requires experimental determination.
Over 1400	Requires experimental determination	Requires experimental determination

NOTE — 1 N/mm² = 0·102 kgf/mm².

ANNEX A

(*Clause* 4.1)

GUIDANCE ON TYPES AND USES OF CHROMIUM COATINGS

A-1 COATINGS NORMALLY USED IN THE AS-PLATED CONDITION

A-1.1 Depending upon the shape, many articles may be chromium plated to tolerances which are acceptable to the engineer. The addition of lapping, honing or polishing can often eliminate the requirement for grinding. Examples of use are as follows:

1. Coatings up to 12 micron thick
   - i) Plastics moulds, where chromium provides a corrosion-resistant surface and allows easy release of the product;
   - ii) rams for use in hydraulic machines.
2. Coatings 12 micron to 50 micron thick
   - i) Cylinder liners for the internal combustion engine;
   - ii) Sideways for machine tools to increase accurate life.
3. Coatings 50 micron to 75 micron thick
   - i) Press tools to reduce friction and improve appearance of pressings;
   - ii) Aircraft undercarriages to improve wear and corrosion resistance.

A-2 COATINGS FINISHED TO SIZE BY GRINDING

A-2.1 The hardness of chromium is such that it may not be turned or milled so that grinding is the only practical method of mechanically to size.

A-2.1.1 *Applications on New Articles*

The thickness; of chromium remaining after grinding should normally be greater than 75 μm.

Examples of use:

i) Hydraulic control valve plungers,

ii) Offset printing cylinders.

A-2.1.2 *Reclamation of Worn or Overmachined Articles*

The thickness required will be that needed to replace lost metal. If heavy coatings are necessary, it is possible to deposit sufficient thickness of an undercoat metal (for example, nickel) such that, after grinding, the final chromium coating will be 75 micron to 250 micron thick. Using chromium alone, the thickness to be applied will be limited by technical and economic requirements, normally to a maximum of 600 micron.

Example of use :

i) Machining errors on crankshaft journals,

ii) Worn turbine rotor bearings.

A-3 USE OF UNDERCOATS

A-3.1 Undercoats of material such as nickel will improve the corrosion resistance of chromium, particularly in a chloride environment where chromium resistance is not good. The nickel undercoat may be specified by the purchaser.

For special applications other metals may be used, for example, copper, bronze and certain sprayed metals.

Examples of use:

1. Sluice-gate hydraulic rams, for sea-locks;
2. Highly-corrosion-resistant pit props.

A-4 TYPES OF CHROMIUM COATINGS

A-4.1 Regular Chromium Coating

Regular chromium is a chromium electrodeposit formed using those operating conditions which produce a coating with a hardness of between 850 HV and 1 100 HV and containing no greater number of cracks than those which are intrinsically unavoidable (*see* **7.1**). This type of chromium electroplate is that normally applied for engineering purposes and is therefore applied unless a purchaser specifies otherwise.

A-4.2 Other Types of Chromium Coating

For special applications, coatings other than regular chromium may be required.

Examples of these are as follows:

a) Crack-free chromium, which is less hard and, being less brittle and essentially free from cracks, offers greater corrosion resistance than regular chromium. Such deposits should not normally exceed 25 micron in thickness and should not be finished by grinding or used on highly-loaded areas. The heat treatment described in **10** may adversely affect the corrosion protection afforded by this type of coating.

b) Porous chromium, which is produced either by mechanical, chemical or electrochemical treatment to obtain an oil-retaining surface. The method for the determination of the degree or type of porosity (for example channel or point) and criteria of acceptance should be specified.

c) Cracked chromium, formed with an intentional crack pattern, micro-cracked chromium has a crack pattern which is invisible to the naked eye, having more than 250 cracks per centimetre in any direction over the whole of the significant surface.

Cracked chromium coatings are usually equivalent in hardness to regular chromium coatings and, due to their structure, retain oil more readily. Micro-cracked chromium coatings confer increased corrosion protection.

d) Duplex chromium, which usually comprises a layer of regular chromium applied over an undercoat of crack free chromium. Its hardness is, therefore, similar to that of regular chromium but it confers greater corrosion protection.

ANNEX B

(*Clause* 5.3)

METHOD FOR ESTABLISHING SHOT PEENING CONDITIONS

B-1 GENERAL

B-1.1 This Annexure describes a method for establishing peening conditions for basis metals, prior to electroplating.

B-2 PRINCIPLE

B-2.1 A rigidly mounted test specimen is peened under specified conditions and its curvature, measured after peening, is used as a measure of peening intensity.

B-3 APPARATUS

B-3.1 The apparatus comprises a test specimen mount as shown in Fig. 1.

B-4 Use a test specimen from carbon steel of hardness range 400 HV 30 to 500 HV 30 and of thickness 1·6 mm, which has been cut to a size of 75 mm × (20 ±0·2) mm and ground to a thickness of 1·3 ± 0·02 mm. The deviation from flatness shall not exceed an arc height of 38 micron when measured as described below.

B-5 PROCEDURE

Fix the specimen rigidly held in the fixture shown in the Fig. I, peen it on the exposed side for the same period and under the same conditions as the part to be electroplated.

After peening, remove the specimen from the fixture and measure the curvature of the unpeened surface with a depth gauge, the specimen being supported on four 5 mm diameter balls, forming a rectangle 32 mm × 16 mm. Align the gauge symmetrically on the specimen with its centre stylus at the centre of the specimen. Measure the arc height at the centre of the specimen over the gauge length of 32 mm, measuring to the nearest 25 micron. Then adjust the peening conditions if necessary, to give the required arc height.

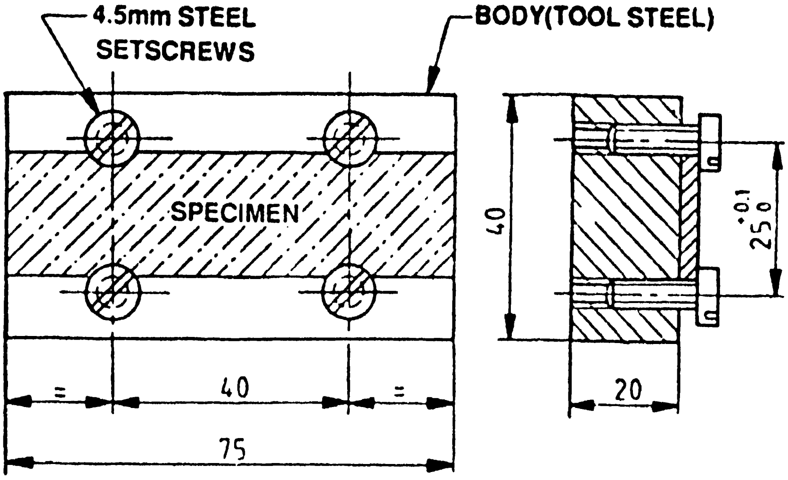

FIG. 1 TEST SPECIMEN MOUNT

ANNEX C

(*Clause* 7.7.1)

FERROXYL TEST

C-0 This method reveals discontinuities, such as pores, in coatings of chromium on iron or steel.

C-1 MATERIAL

C-1.1 The test solution is prepared by dissolving 10 g of agar, 10 g of sodium chloride (Nacl), and 1 g of potassium ferricyanide $[K_3Fe (CN)_6]$ in 1 L of warm distilled water.

C-1.2 Procedure

C-1.2.1 Clean and degrease with methyl alcohol or any suitable solvent the surface to be tested. Slowly warm the test solution to 93°C to liquefy it. Apply the warmed test solution to the specimen by one of the following methods; (a) dip the specimen into the solution; (b) pour the solution over the specimen or (c) dip a piece of filter paper into the solution; allow the excess to drain off, and then apply the wet paper to the test area and allow to remain undisturbed. (Do not apply the solution if its temperature is below 60°C.) Place the test specimen in a horizontal position at 21 to 27°C for the specified period. At the end of this period examine the coating or remove the filter paper and examine the side that was in contact with the specimen. Blue spots indicate basis metal corrosion or porosity.

C-1.3 Report

C-1.3.1 The report shall include the following.

C-1.3.1.1 The total number and the diameter of all spots visible to the unaided eye.

C-1.3.1.2 Highest number of spots visible at one time through a template with 25 mm x 25 mm opening in it, when placed on the surface.

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